NAVY RESEARCH FOR MATERIALS BEYOND NI- SUPERALLOYS

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Creation and development of high temperature materials is critical to many processes and applications important to DoD. The dramatic growth of computational modeling programs and 2D and 3D characterization tools that can examine atomistic features to the continuum scales has had a big impact on this materials research and holds promise in creating new materials and/or new or more efficient materials processing pathways.

Propulsion materials for both Naval aircraft and ship gas turbine engines are subjected to the corrosive environment of the sea to differing degrees. All potential materials tend to become unstable in many high temperatures environments, particularly in the salt-laden marine environment, without the presence of a stable, protective coating on the component surface. Materials life is dependent on dynamic combinations of many inherent factors such as temperature, environment, and stress and need to be to be resistant to oxidation, corrosion, or alternating cycles of oxidation and corrosion. Research seeks to explore and understand the thermodynamics and kinetics of materials interactions and materials stability in Naval environments and temperatures in order to develop models that lead to creating new materials or establishing life prediction capabilities for existing and novel materials.

Materials capable of high temperatures performance above that possible with nickel-based superalloys (~1100°C) will play a key role in enabling further advances in gas turbine engine capabilities. Such materials will lead to improvements in engine efficiency, reduced fuel costs, and decreased costs in maintenance and total life cycle. Mo- and Nb-based based intermetallic alloys offer the possibility of higher temperature performance above 1100°C. The Mo-Si-B alloy system has high temperature stability (melting temperature, T_m, is above 2000°C) and attractive materials properties for different combinations of equilibrated phases.

Recently a new class of high entropy alloys (HEAs) has received a lot of attention and its design potentially offers opportunities to high temperature strength properties exceeding that of traditional superalloys. The HEA systems contain at least five principle elements, each of which has an atomic percentage between 5 at.% and 35 at.% . It has been reported that HEAs possess other desirable properties, such as high hardness, outstanding wear resistance, good fatigue resistance characteristics, good thermal stability and, in general, good oxidation and corrosion. This paper will address the research needed to advance these alloys for U.S. Naval applications.